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Starter of single-phase induction motor

TECHNICAL FIELD

The present invention relates to a starter of single-phase induction motor, such as compressor motor for refrigerator (enclosed motor compressor) or pump motor.

BACKGROUND ART

Starters are often used in single-phase induction motors for driving, for example, refrigerator, air conditioner, and other enclosed compressor. This kind of starter is hitherto structure as shown in Fig. 27 (A), a positive characteristic thermistor 312 is connected in series to an auxiliary winding S energized by alternating-current power source 90 together with main winding M. In such starter, when starting up the single-phase induction motor 100, the positive characteristic thermistor 312 presents a low electrical resistance, and a starting current flows in the auxiliary winding S. By the starting current, the positive characteristic thermistor 312 becomes high in resistance, and the current to the auxiliary winding S is limited. In this configuration, also during stationary operation after completion of starting of single-phase induction motor, the positive characteristic thermistor 312 is applied with supply voltage and continues to generate heat by itself, and power of about 2 to 4 W is always consumed, and there is problem in energy saving.

Further, in the conventional starter, right after stopping of single-phase induction motor 100, re-starting was difficult. That is, the positive characteristic thermistor 312 for starting is large in thermal capacity, once reaching high temperature and high resistance during operation, after stopping of motor 100, the temperature drops nearly to ordinary temperature, and it takes dozens of seconds to several minutes until ready to start

again, and if attempted to start again before this time, since the positive characteristic thermistor 312 is high in resistance, only small current flows in the auxiliary winding S, and the rotor of the motor 100 is confined, and a large current flows through the main winding M, and overload relay 50 is actuated to arrest re-starting. The reset time of overload relay is initially slightly shorter than the cooling period until the positive characteristic thermistor 312 is ready to re-start, and the overload relay operates and resets repeatedly, and the temperature becomes higher gradually, and the reset time is longer. As the reset time of overload relay becomes longer than the positive characteristic thermistor 312, the motor 100 is ready to start. A similar phenomenon occurs in a compressor motor for refrigerator, that is, when the compartment temperature drops, the thermostat is cut off, and the compressor motor stops, and immediately when the door is opened, the compartment temperature rises, and the thermostat is turned on. In such a case, not only it takes longer time for re-starting, but also the life of the overload relay is shortened.

Accordingly, the present applicant previously proposed a starter for single-phase induction motor having the structure as shown in Fig. 27 (B), by fling a patent in Japanese unexamined patent publication No. H6-38467. In this circuit, a bimetal 218 is provided in series to positive characteristic thermistor 312 in starter 210, and by heating the bimetal 218 by the positive characteristic thermistor 312 and resistance 214 connected in parallel, the current to the positive characteristic thermistor 312 is cut off. By the resistance 214 of smaller power consumption than the positive characteristic thermistor 312, the OFF state of the bimetal 218 is maintained, and power consumption has been saved. Further, Japanese unexamined utility model publication No. S56-38276 discloses a starter having positive characteristic thermistor disposed in two divisions.

Further, in the starter having positive characteristic thermistor, for the ease of mounting on single-phase induction motor, socket terminals may be provided to be connected to the connection pins provided at the side of the single-phase induction motor. For example, as disclosed in Japanese unexamined utility model publication No. S62-115760, three connection pins project from the single-phase induction motor, and they are electrically connected by way of socket terminals of the starter.

Electrical devices receive very larger vibrations from the motor and others. Therefore if the holding strength of socket terminals is weak due to trouble of device, when dismounting for checking, or when reassembling after removal, and the contact of starter and electrical devices may be insufficient. In particular, in starter for staring a large motor, the contact area is heated and terminal is damaged, and function as PTC relay device cannot be exhibited. Further, possibility of fire or other accident cannot be negated.

A plan view of socket terminal incorporated in a conventional starter of prior art is shown in Fig. 28 (A), a sectional view in Fig. 28 (B), and a bottom view in Fig. 28 (C). This socket terminal 122 is connected to connection pin 212 as shown in Fig. 28 (F), and at this time stress by galling (galling force) mainly occurs in two directions X and Y. As a result, the socket terminal 122A may not restore the original position if attempted to open due to effects of galling force as shown in Fig. 28 (G). Hence, the gripping force of connection pin 212 by socket terminal 122A is substantially lowered, and the contact resistance increases due to faulty contact, and when current flows, heat is generated, and damage of terminal and other problems may occur.

To solve these problems, various patents have been proposed such as Japanese unexamined patent publication No. H8-149770,

and Japanese unexamined patent publication No. 2001-332159. Japanese unexamined patent publication No. H8-149770 proposes a tubular socket terminal having four grooves provided along the inserting and removing direction of connection pin. Japanese unexamined patent publication No. H8-149770 also proposes a technology having a pair of junction tongues for opening and absorbing stress if galling force occurs in the gripping portion by composing the socket terminal by gripping portion and support portion. Japanese unexamined patent publication No. 2001-332159 proposes a technology having a bump for preventing the socket terminal from opening near the slit opening of the socket terminal.

However, in the starter disclosed in Japanese unexamined patent publication No. H6-38467, in order to maintain the OFF state of the bimetal 218 by resistance 214, as compared with the circuit configuration in Fig. 27 (A), there was limitation in saving power consumption to 1/3. In Japanese unexamined utility model publication No. S56-38276, since the positive characteristic thermistor is divided into two sections, the power consumption could be saved only to half.

Not limited to the power consumption, in the starter of Japanese unexamined patent publication No. H6-38467, since the thermal capacity is large in the resistance 214 for maintaining the OFF state of the bimetal 218, the single-phase induction motor could not be re-started quickly. In Japanese unexamined utility model publication No. S56-38276, since the positive characteristic thermistor is divided into two sections, the re-starting time could be decreased only to half.

The invention is devised to solve the problems of the prior art, and it is hence an object thereof to present a starter for single-phase induction motor capable of saving energy by extremely suppressing consumption power during stationary operation by positive characteristic thermistor for starting.

The tubular socket terminal disclosed in Japanese unexamined patent publication No. H8-149770 is likely to be deformed by concentration of stress in part due to rib effect in the arc portion divided by groove. The socket terminal having the junction tongues of Japanese unexamined patent publication No. H8-149770 has the junction tongues projecting sideways, and the space efficiency is poor, and it is hard to store into the starter. The socket in Japanese unexamined patent publication No. 2001-332159 has a bump formed separately from the socket terminal, and the space efficiency is poor, and it is hard to store into the starter.

The invention solves these problems, and it is hence a still further object thereof to present a starter for single-phase induction motor of high reliability capable of maintaining the gripping force of socket terminal for a long period of time.

DISCLOSURE OF THE INVENTION

In order to achieve the above objects, according to Claim 1, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a casing,

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor,

a snap action bimetal connected in series to a series circuit of auxiliary winding and positive characteristic thermistor for sensing the heat from the auxiliary positive characteristic thermistor and turning off when reaching a set temperature, and

an enclosed compartment accommodated in the casing, for

enclosing the snap action bimetal and auxiliary positive characteristic thermistor.

In order to achieve the above objects, according to Claim 5, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a casing,

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor,

a bimetal connected in series to a series circuit of auxiliary winding and positive characteristic thermistor for sensing the heat from the auxiliary positive characteristic thermistor and turning off when reaching a set temperature,

an enclosed compartment accommodated in the casing, for enclosing the bimetal and auxiliary positive characteristic thermistor, and

a magnet for applying magnetic force to the bimetal so as to force the contact point to the ON side.

According to Claim 7, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a casing,

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor,

a temperature sensing magnet for sensing the heat from the auxiliary positive characteristic thermistor and demagnetizing when reaching a set temperature,

a switch connected in series to a series circuit of auxiliary winding and positive characteristic thermistor, and

turning on as being attracted by the magnetic force of the temperature sensing magnet, and turning off by demagnetization of the temperature sensing magnet, and

an enclosed compartment accommodated in the casing, for enclosing the switch.

According to Claim 8, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor,

a temperature sensing magnet for sensing the heat from the auxiliary positive characteristic thermistor and demagnetizing when reaching a set temperature, and

a reed switch connected in series to a series circuit of auxiliary winding and positive characteristic thermistor, and turning on as being attracted by the magnetic force of the temperature sensing magnet, and turning off by demagnetization of the temperature sensing magnet.

In the starter for single-phase induction motor as set forth in Claim 1 of the invention, when starting up the single-phase induction motor, since the positive characteristic thermistor is low in resistance, a starting current flows through the auxiliary winding by way of a series circuit of positive characteristic thermistor and snap action bimetal, and the single-phase induction motor is started up. By flow of starting current, the positive characteristic thermistor generates heat by itself, and becomes high in resistance, and more current flows into the auxiliary positive characteristic thermistor side connected parallel to the positive characteristic thermistor. When the auxiliary positive characteristic thermistor reaches a set temperature, the snap action bimetal is cut off, and no

current flows into the positive characteristic thermistor, and the single-phase induction motor starts up completely, and gets into stationary operation.

When the snap action bimetal is cut off, current flows only into the auxiliary positive characteristic thermistor side to generate heat, and by this heat generation, the snap action bimetal is kept in OFF state.

Therefore, during stationary operation of single-phase induction motor, no current flows into the positive characteristic thermistor and instead current flows into the auxiliary positive characteristic thermistor side, but the current flowing in the auxiliary positive characteristic thermistor is very small only enough to generate heat in the auxiliary positive characteristic thermistor for holding the OFF state of the snap action bimetal, and power consumption by the auxiliary positive characteristic thermistor is extremely smaller than the power consumption by the conventional positive characteristic thermistor.

In particular, since the snap action bimetal and auxiliary positive characteristic thermistor are contained in a same enclosed compartment in the casing, heat hardly radiates outside, and the OFF state of the snap action bimetal can be maintained by a very small power consumption. Further, as the refrigerant of enclosed compressor, flammable gas (hydrocarbon compound such as butane) is used, and if the refrigerant leaks, it is contained within the enclosed compartment, ignition by spark in opening and closing action of snap action bimetal is prevented.

Further, during stationary operation of single-phase induction motor, the positive characteristic thermistor for starting in large thermal capacity is cooled, and temperature is ordinary. On the other hand, since the auxiliary positive characteristic thermistor is small in thermal capacity, it is quick to cool. Therefore, when attempted to start up again right

after stopping the single-phase induction motor, the auxiliary positive characteristic thermistor is immediately cooled nearly to ordinary temperature, and it is ready to start up very quickly in several seconds to dozens of seconds, and it is possible to re-start quickly without repetition of operation and reset of overload relay as in the prior art.

Moreover, a small-sized auxiliary positive characteristic thermistor is used for heating the bimetal, it is effective for correcting changes in response to ambient temperature, without effects of voltage fluctuations.

According to Claim 2, the starter of single-phase induction motor, wherein the snap action bimetal is composed of a movable contact plate for oscillating a movable contact point, a bimetal, and a plate spring of semicircular section interposed between first support point of the movable contact plate and second support point of the bimetal,

the movable contact plate is forced so as to cause the plate spring to push the movable contact point to the fixed contact point side when the second support point is shifted to the leading end position side at low temperature of the bimetal, than the line segment linking the support point of the movable contact plate and the first support point, and

the movable contact plate is forced so as to cause the plate spring to depart the movable contact point from the fixed contact point side when the second support point is shifted to the leading end position side at high temperature of the bimetal, than the line segment linking the support point of the movable contact plate and the first support point. Accordingly, the snap action bimetal can cut off the contact quickly. Therefore, the arc does not continue, rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from

defect for a long period of time.

In Claim 3, the starter of single-phase induction motor, wherein the snap action bimetal is a bimetal processed by drawing. In Claim 4, the starter of single-phase induction motor, wherein the snap action bimetal is a bimetal processed by forming in a circular form in the center. Accordingly, the snap action bimetal can cut off the contact quickly. Therefore, the arc does not continue, rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

In Claim 5, the bimetal having contact at free end side is forced to the contact ON side by the magnetic force of the magnet. When the bimetal is cut off, the magnetic force from the magnet is lowered inversely proportional to the square of the distance. The bimetal receives the strongest magnetic force in contact ON state, and after the contact leaves, the magnetic force decreases rapidly, so that the contact can be cut off quickly. Therefore, the arc does not continue, rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

In Claim 6, an auxiliary positive characteristic thermistor contacts with the base of the bimetal. Hence, heat from the auxiliary positive characteristic thermistor can be efficiently transmitted to the bimetal, and the OFF state of the bimetal can be maintained by the auxiliary positive characteristic thermistor of small power consumption.

In Claim 7, for example, a switch having a contact at free end side of spring plate made of magnetic conductive member senses heat from the auxiliary positive characteristic thermistor, and

when reaching the set temperature, it is forced by the magnetic force of the temperature sensing magnet which is demagnetized. That is, at less than the set temperature, the switch resists the elastic force of the spring plate, and is attracted by the magnetic force of temperature sensing magnet, and is turned on, and when exceeding the set temperature, the switch is turned off by the elastic force of spring plate by demagnetization of the temperature sensing magnet. At this time of turning off, the magnetic force from the temperature sensing magnet drops inversely proportional to the square of the distance. The switch has the strongest magnetic force in contact ON state, and after the contact leaves, the magnetic force drops rapidly, so that the contact can be cut off quickly. Therefore, the arc does not continue, rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

In Claim 8, a reed switch senses the heat from the auxiliary positive characteristic thermistor, it is turned on or off by the magnetic force of temperature sensing magnet which is demagnetized when reaching the set temperature. At lower than the set temperature, the reed switch is turned on by the magnetic force of temperature sensing magnet, and when exceeding the set temperature, the reed switch is turned off by demagnetization of the temperature sensing magnet. At this time of turning off, the magnetic force from the temperature sensing magnet drops inversely proportional to the square of the distance, and the reed switch is cut off quickly. Therefore, the arc does not continue, rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for

a long period of time.

In Claim 9, the starter of single-phase induction motor, wherein a through-hole is pierced in a specified position of a conductor plate having a spring member for connecting electrically while holding the positive characteristic thermistor by elastic force, and a fuse is provided by narrowing the width in the outer circumference of the through-hole. Hence, in the event of abnormal heat generation of positive characteristic thermistor, thermal runaway, or elevation of resistance to cause nearly short-circuited state to increase current, the fuse melts down. Hence, burning starting winding or starting relay can be prevented.

In Claim 10, slots are provided in the contacting corners bent at obtuse angle for contacting with positive characteristic thermistor in the spring section for holding the positive characteristic thermistor. As a result, contact points with positive characteristic thermistor of contacting corners are divided and doubled in number, so that the contact reliability can be enhanced.

In Claim 11, notches are provided in the contacting corners bent at obtuse angle for contacting with positive characteristic thermistor in the spring section for holding the positive characteristic thermistor. As a result, contact points with positive characteristic thermistor of contacting corners are divided and doubled in number, so that the contact reliability can be enhanced. Further, the resonance frequency of contacting corners is different between the inside and outside of the notch. Compressor vibration is transmitted to the starter, and the positive characteristic thermistor and spring member resonance, and if the positive characteristic thermistor electrode is hit by spring member, the electrode may damaged or separated, but in Claim 11, since the resonance frequency is different between the inside and outside of contacting corners, they do not resonate

at the same time, and the contacting corners will not hit the positive characteristic thermistor, and electrodes of positive characteristic thermistor will not be damaged.

In order to achieve the above objects, according to Claim 12, a starter of single-phase induction motor having main winding and auxiliary winding, comprising a positive characteristic thermistor connected in series to the auxiliary winding, and a socket terminal for connecting electrically with a detachable connection pin,

wherein the socket terminal has a pair of plates extending sideways in the axial direction of connection pin bent to the inner side, has the leading end formed in an arc shape so as to conform to the columnar shape of the connection pin, and is provided with a connection pin holder having the leading ends spaced from each other, and

the connection pin holder is divided into two sections by the slit in the connection pin axial direction and vertical direction, into leading end side first position, and inner side second position.

In the starter of Claim 12, since the connection pin holder of the socket terminal is divided into two sections, first portion at leading end side and second portion at inner side, and if galling force acts when inserting the connection pin, spreading is limited to the first portion at leading end side and spreading is not extended to second portion at inner side. In the second portion, hence, fatigue does not occur, and favorable contact state with connection pin can be held, and damage by heating of contact portion does not occur.

Further, when inserting into the connection pin, the first portion at the leading end side is spread and inserted, and when the connection pin leading end reaches the second portion, the second portion begins to spread. That is, the force required for inserting is strongest at the beginning and then remains

nearly unchanged in order to push open the portion narrower than the connection pin, but in the invention, it is enough to push open only the first portion at the leading end side being divided, at the initial time of inserting the connection pin, and as compared with the conventional product required to push open the entire connection pin holder, the inserting process is easier. Since the size is same as in the conventional product, the space efficiency is high, and it is easy to apply in the existing starter.

If there is inclination between the connection pin and socket terminal, since the first portion at the leading end and the second portion at the inner side independently contact with the connection pin, if the connection pin and socket terminal contact with each other point to point, the contact point is doubled in number, and the electric connection of connection pin and socket terminal can be assured.

In Claim 13, since the recess of accommodating the leading end of the connection pin penetrating through the connection pin holder is provided in the casing, the chamfered portion of the leading end of the connection pin penetrates through the connection pin holder and is positioned in the recess. That is, the since the chamfered portion is not held by the connection pin holder, the gripping force of the connection pin by the connection pin holder can be enhanced, and it is also effective to lower the contact resistance.

In Claim 14, since the first portion at the leading end side of the connection pin holder is formed wider so as to hold the connection pin more moderately than the inner side second portion, and only a small effort is needed when inserting to insert the connection pin. On the other hand, the inner side second portion is formed narrowly, and a favorable contact state with the connection pin can be held at the second portion, so that damage by heating in the contact portion does not occur.

In Claim 15, since the length of the connection pin holder

in the connection pin axial direction of the first portion at leading end is formed longer than the inner side second portion, the galling force when inserting the connection pin is held in the first portion, and spreading of galling to the second portion is arrested. As a result, favorable contact state with the connection pin can be maintained in the second portion, and damage due o heating of connection portion does not occur.

In Claim 16, since the length of the connection pin holder in the connection pin axial direction of the second portion at the inner side is formed longer than the leading end first portion at the inner side, by firmly holding the connection pin at the second portion, fatigue does not occur, and favorable contact state with the connection pin is maintained, and damage by heating of contact portion does not occur.

In Claim 17, since V-notch is provided at the leading end of the second portion at the inner side of the connection pin holder, when inserting into the connection pin, if the connection pin leading end reaches the second potion after inserting into the first portion of the leading end side, it can be easily inserted into the second portion side, and the inserting work is easy.

In order to achieve the above objects, according to Claim 19, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a casing,

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor,

a slow action bimetal connected in series to a series circuit of auxiliary winding and positive characteristic thermistor for sensing the heat from the auxiliary positive

characteristic thermistor and turning off when reaching a set temperature, and

an enclosed compartment accommodated in the casing, for enclosing the slow action bimetal and auxiliary positive characteristic thermistor.

In the starter of single-phase induction motor as set forth in Claim 19, when starting up the single-phase induction motor, the positive characteristic thermistor is low in resistance, and a starting current flows through the auxiliary winding by way of series circuit of positive characteristic thermistor and slow action bimetal, and the single-phase induction motor is started up. When the starting current flows, the positive characteristic thermistor generates heat by itself, and becomes high in resistance, and more current flows into the auxiliary positive characteristic thermistor side connected parallel to the positive characteristic thermistor. When the auxiliary positive characteristic thermistor reaches a set temperature, the slow action bimetal is cut off, and no current flows into the positive characteristic thermistor, and the single-phase induction motor is started up completely and gets into stationary operation.

When the slow action bimetal is cut off, current flows only into the auxiliary positive characteristic thermistor side to generate heat, and by this heat generation, the slow action bimetal is kept in OFF state.

Therefore, during stationary operation of single-phase induction motor, no current flows into the positive characteristic thermistor and instead current flows into the auxiliary positive characteristic thermistor side, but the current flowing in the auxiliary positive characteristic thermistor is very small only enough to generate heat in the auxiliary positive characteristic thermistor for holding the OFF state of the slow action bimetal, and power consumption by the

auxiliary positive characteristic thermistor is extremely smaller than the power consumption by the conventional positive characteristic thermistor.

In particular, since the slow action bimetal and auxiliary positive characteristic thermistor are contained in a same enclosed compartment in the casing, heat hardly radiates outside, and the OFF state of the slow action bimetal can be maintained by a very small power consumption. Further, as the refrigerant of enclosed compressor, flammable gas (hydrocarbon compound such as butane) is used, and if the refrigerant leaks, it is contained within the enclosed compartment, ignition by spark in opening and closing action of slow action bimetal is prevented.

Further, since slow action bimetal is used, as compared with the formed snap action bimetal, it withstands use for a longer period of time.

Further, during stationary operation of single-phase induction motor, the positive characteristic thermistor for starting in large thermal capacity is cooled, and temperature is ordinary. On the other hand, since the auxiliary positive characteristic thermistor is small in thermal capacity, it is quick to cool. Therefore, when attempted to start up again right after stopping the single-phase induction motor, the auxiliary positive characteristic thermistor is immediately cooled nearly to ordinary temperature, and it is ready to start up very quickly in several seconds to dozens of seconds, and it is possible to re-start quickly without repetition of operation and reset of overload relay as in the prior art.

In Claim 20, an auxiliary positive characteristic thermistor contacts with the base of the slow action bimetal. Hence, the heat from the auxiliary positive characteristic thermistor can be efficiently transmitted to the slow action bimetal, and the OFF state of the slow action bimetal can be maintained by the auxiliary positive characteristic thermistor

of small power consumption.

In order to achieve the above objects, according to Claim 21, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor,

a slow action bimetal connected in series to a series circuit of auxiliary winding and positive characteristic thermistor for sensing the heat from the auxiliary positive characteristic thermistor and turning off when reaching a set temperature, and

a snap action bimetal connected in series to a series circuit of auxiliary winding, positive characteristic thermistor, and slow action bimetal for sensing the heat from the positive characteristic thermistor and turning off when reaching a specified high temperature.

In the starter of single-phase induction motor as set forth in Claim 21, when starting up the single-phase induction motor, the positive characteristic thermistor is low in resistance, and a starting current flows through the auxiliary winding by way of series circuit of positive characteristic thermistor and slow action bimetal, and the single-phase induction motor is started up. When the starting current flows, the positive characteristic thermistor generates heat by itself, and becomes high in resistance, and more current flows into the auxiliary positive characteristic thermistor side connected parallel to the positive characteristic thermistor. When the auxiliary positive characteristic thermistor reaches a set temperature, the slow action bimetal is cut off, and no current flows into the positive characteristic thermistor, and the single-phase

induction motor completes starting-up and gets into stationary operation.

When the slow action bimetal is cut off, current flows only into the auxiliary positive characteristic thermistor side to generate heat, and by this heat generation, the slow action bimetal is kept in OFF state.

Therefore, during stationary operation of single-phase induction motor, no current flows into the positive characteristic thermistor and instead current flows into the auxiliary positive characteristic thermistor side, but the current flowing in the auxiliary positive characteristic thermistor is very small only enough to generate heat in the auxiliary positive characteristic thermistor for holding the OFF state of the slow action bimetal, and power consumption by the auxiliary positive characteristic thermistor is extremely smaller than the power consumption by the conventional positive characteristic thermistor. Further, since slow action bimetal is used, as compared with the formed snap action bimetal, it withstands use for a longer period of time.

When the positive characteristic thermistor generates heat abnormally and reaches given high temperature, the snap action bimetal is cut off, and current to the auxiliary winding is cut off, thereby preventing the positive characteristic thermistor from running away thermally, to be high in temperature and low in resistance, and breading down insulation by flow of excessive current through the auxiliary winding.

In Claim 22, the snap action bimetal is set so that it may not reset at ordinary temperature. Hence, thermal runaway of positive characteristic thermistor by reset by snap action bimetal can be prevented completely.

In Claim 23, the starter of single-phase induction motor, wherein the contact point of the slow action bimetal and contact point of the snap action bimetal directly contact with each other,

when the slow action bimetal reaches the set temperature, it is departed from the contact point at the snap action bimetal side, and

when the snap action bimetal reaches the specified high temperature, it is departed from the slow action bimetal side. When the slow action bimetal is cut off by application of heat, heat is also applied to the snap action bimetal side, and it is slightly moved to the side departing from the slow action bimetal side, and by using a slow action bimetal slow in action though long in life, the starting current can be cut off appropriately. That is, along with temperature rise, both bimetals move in mutually departing direction, and chattering hardly occurs. Further, since both contacts are made of movable contacts, wiping (rubbing) phenomenon always occurs by temperature changes, the contact contacting portions are cleaned, and a long life is realized by using silver contact without gold plating. Further, since the contact points of slow action bimetal and contact points of snap action bimetal directly contact with each other, lower cost and lower resistance are realized as compared with the case of interposing terminal members of metal plates or the like providing fixed contacts at both sides.

In Claim 24, a stopper is provided to contact with the leading end of the snap action bimetal, so as not to disturb the operation of the slow action bimetal. It is hence possible to prevent warping to the slow action bimetal side if the snap action bimetal returns to ordinary temperature due to cooling of positive characteristic thermistor after completion of starting.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 (A) is an explanatory diagram showing mounting of starter and overload relay on compressor in the first embodiment, FIG. 1 (B) is a perspective view of pin terminal.

FIG. 2 is a circuit diagram of starter and overload relay

in the first embodiment.

FIG. 3 is a plan view of starter and overload relay in the first embodiment.

FIG. 4 (A), FIG. 4 (B) are X-X longitudinal sectional views of cover mounting state of overload relay shown in FIG. 3, specifically FIG. 4 (A) showing a state before inversion of bimetal, FIG. 4 (B) showing a state after inversion of bimetal.

FIG. 5 (A) is a bottom view removing bottom cover of starter of single-phase induction motor of the first embodiment of the invention, FIG. 5 (B) is a sectional view of B1-B1 in FIG. 5 (A), and FIG. 5 (C) is a sectional view of C1-C1 in FIG. 5 (B).

FIG. 6 (A) is a plan view from arrow e-side of FIG. 5 (B), FIG. 6 (B) is a side view from arrow f-side in FIG. 5 (C), and FIG. 6 (C) is a bottom view from arrow g-side in FIG. 5 (B).

FIG. 7 (A) is a plan view of assembled state of overload relay in starter, FIG. 7 (B) is a side view, and FIG. 7 (C) is a bottom view.

FIG. 8 (A) is a plan view of snap action bimetal, and FIG. 8 (B), FIG. 8 (C) are magnified sectional views of starter shown in FIG. 5 (C).

FIG. 9 (A) is a magnified view of first connection plate shown in FIG. 5 (A), FIG. 9 (B) is an arrow h-view of FIG. 9 (A), FIG. 9 (C) is an arrow j-view of FIG. 9 (A), and FIG. 9 (D) is a magnified perspective view of abutting portion with main PTC surrounded by circle D in FIG. 9 (C).

FIG. 10 (A) is a plan view of snap action bimetal in a modified example of the first embodiment, and FIG. 10 (B) and FIG. 10 (C) are sectional views of starter in the modified example of the first embodiment.

FIG. 11 (A) is a magnified view of first connection plate in a modified example of the first embodiment, FIG. 11 (B) is an arrow h-view of FIG. 11 (A), FIG. 11 (C) is an arrow j-view of FIG. 11 (A), and FIG. 11 (D) is a magnified perspective view

of abutting portion with main PTC surrounded by circle D in FIG. 11 (C).

FIG. 12 (A) is a plan view of snap action bimetal of starter in the second embodiment, FIG. 12 (B) is a side view, FIG. 12 (C) is a plan view of snap action bimetal of starter in other example of the second embodiment, FIG. 12 (D) is a side view of other example, and FIG. 12 (E) and FIG. 12 (F) are explanatory diagrams of operation of snap action bimetal of the second embodiment.

FIG. 13 (A) is a plan view of snap action bimetal of starter in a modified example of the second embodiment, FIG. 13 (B) is a side view, and FIG. 13 (C) and FIG. 13 (D) are explanatory diagrams of operation of snap action bimetal in the modified example of the second embodiment.

FIG. 14 (A) and FIG. 14 (B) are explanatory diagrams of operation of bimetal of starter in the third embodiment.

FIG. 15 (A) and FIG. 15 (B) are explanatory diagrams of operation of switch of starter in the fourth embodiment.

FIG. 16 is an explanatory diagram of reed switch of starter in the fifth embodiment.

FIG. 17 (A), FIG. 17 (B), and FIG. 17 (C) are circuit diagrams of application examples of starter in this embodiment.

FIG. 18 (A) is a magnified perspective view of abutting portion surrounded by circle E in FIG. 5 (B), FIG. 18 (B) is a sectional view B3-B3 in FIG. 18 (A), FIG. 18 (C) is a sectional view C3-C3 in FIG. 18 (A) (with the inner side from the pin center being cut off), and FIG. 18 (D) is a perspective view of socket terminal of the pin inserted state.

FIG. 19 (A) is a plan view of terminal shown in FIG. 18 (A), FIG. 19 (B) is a sectional view B4-B4 in FIG. 19 (A), and FIG. 19 (C) is an arrow k-view of FIG. 19 (A).

FIG. 20 (A) is a plan view of terminal of the second embodiment, FIG. 20 (B) is a sectional view B4-B4 in FIG. 20 (A),

and FIG. 20 (C) is an arrow k-view of FIG. 20 (A).

FIG. 21 (A) is a plan view of terminal of the third embodiment, FIG. 21 (B) is a sectional view B4-B4 in FIG. 21 (A), and FIG. 21 (C) is an arrow k-view of FIG. 21 (A).

FIG. 22 is a graph comparing insertion force of socket terminal in the first embodiment with socket terminal in prior art.

FIG. 23 (B) is a plan view with the lid removed of starter in the sixth embodiment of the invention, FIG. 23 (A) is a sectional view A-A in FIG. 23 (B), and FIG. 23 (C) is a sectional view C-C in FIG. 23 (B).

FIG. 24 (A) and FIG. 24 (B) are side views of starter in the sixth embodiment.

FIG. 25 (B) is a plan view with the lid removed of starter in the seventh embodiment of the invention, FIG. 25 (A) is a sectional view A-A in FIG.25 (B), and FIG. 25 (C) is a sectional view C-C in FIG. 25 (B).

FIG. 26 is a circuit diagram of starter in the seventh embodiment.

FIG. 27 (A) is a circuit diagram of starter in prior art, and FIG. 27 (B) is a circuit diagram of starter disclosed in Japanese unexamined patent publication No. H6-38467.

FIG. 28 (A) is a plan view of socket terminal in prior art, FIG. 28 (B) is a sectional view, FIG. 28 (C) is a bottom view, FIG. 28 (D) and FIG. 28 (E) are sectional views showing connection pin inserted state into the starter, and FIG. 28 (F) and FIG. 28 (G) are perspective view showing connection pin inserted state into socket terminal.

BEST MODE FOR CARRYING OUT THE INVENTION

[First embodiment]

Referring now to the drawings, the starter and overload relay of the first embodiment of the invention are explained below.

As shown in FIG. 1 (A), a starter 10 and an overload relay 50 of the first embodiment are integrally attached to a pin terminal 110 of dome 104 of compressor 102, and protected with cover 106. A motor 100 is accommodated in the compressor 102.

FIG 2 is a circuit diagram of starter and overload relay 50 of single-phase induction motor in the first embodiment. Power source terminals 92, 94 are connected to 100 V single-phase alternating-current power source 90, and one power source terminal 92 is connected to power line 96 in series to operation switch 97 and overload relay 50, and other power source terminal 94 is connected to power line 98. The overload relay 50 comprises a bimetal 70 and a heater 76 for heating the bimetal 70, and when the single-phase induction motor 100 is overloaded, the heater 76 is heated and the bimetal 70 cuts off the current, and when the temperature is lowered to ordinary temperature by interruption of current, the bimetal 70 resets automatically, and current flow is resumed.

The single-phase induction motor 100 includes main winding M and auxiliary winding S, the main winding M is connected between the power lines 96 and 98, and one terminal of the auxiliary winding S is connected to the power line 96. The single-phase induction motor 100 is designed to drive an enclosed compressor 102, for example, by referring to refrigeration cycle in refrigerator as shown in Fig. 1. The operation switch 97 is turned on or off by temperature control device not shown in the diagram, and it is turned on when the refrigerator compartment temperature reaches an upper limit, and is turned off when lowered to lower limit temperature.

Other terminal of the auxiliary winding S is connected to the power line 98 by way of a series circuit of positive characteristic thermistor (main PTC) 12 and normally-closed snap action bimetal 18. Parallel to the main PTC 12 and snap action bimetal 18, an auxiliary positive characteristic thermistor

(auxiliary PTC) 14 is connected. The main PTC 12 and auxiliary PTC 14 are composed, for example, of oxide semiconductor ceramic mainly made of barium titanate, having curie temperature, and the electrical resistance is suddenly increase from the curie temperature. For example, the positive characteristic thermistor 12 is about 5 ohms at ordinary temperature (around 25 deg. C), about 0.1 kohm at 120 deg. C, and about 1 to 10 kohms at 140 deg. C. The auxiliary PTC 14 has higher resistance values than the main PTC 12, and the thermal capacity is set at about 1/3 to 1/10 (optimally about 1/6) so that the power consumption may be 1/3 to 1/10. The snap action bimetal 18 senses the generated heat of the auxiliary PTC 14, and is turned on or off, and, for example, it is designed to be turned off when the detected heat reaches the set temperature of 140 deg. C.

The operation of the starter 10 in the first embodiment is explained. When the operation switch 97 is turned on, a starting current flows through the main winding M by way of the operation switch 97 and overload relay 50. Since the main PTC 12 is low in resistance (for example, about 5 ohms) at ordinary temperature, and starting current flows in both series circuit of auxiliary winding S, main PTC 12, and snap action bimetal 18, and parallel circuit of auxiliary PTC 14, and thereby the single-phase induction motor 100 is started up.

When starting current of auxiliary winding S flows into the main PTC 12, the main PTC 12 and auxiliary PTC 14 generate heat, and the electrical resistance increases rapidly. Several seconds later, the main PTC 12 and auxiliary PTC 14 reach the temperature of 140 deg. C, and the electrical resistance of the main PTC 12 at this time is, for example, 1 to 10 kohms, and the current flowing in the snap action bimetal 18 decreases. When the auxiliary PTC 14 reaches the temperature of 140 deg. C, the snap action bimetal 18 senses it and is turned off, and no longer current flows into the series circuit of main PTC 12 and snap

action bimetal 18, and the single-phase induction motor 100 is started up completely, and gets into stationary operation.

When the snap action bimetal 18 is turned off, current flows only into the auxiliary PTC 14 side, and heat is generated, and the snap action bimetal 18 senses the generated heat, and is kept in OFF state.

Therefore, during stationary operation of the single-phase induction motor 100, no current flows into the main PTC 12, and instead current flows into the auxiliary PTC 14 side, but the current flowing in the auxiliary PTC 14 side is very small only enough to generate heat for keeping the OFF state of the snap action bimetal 18, and the power consumption by the auxiliary PTC 14 is extremely smaller than the power consumption by the conventional positive characteristic thermistor.

During stationary operation of the single-phase induction motor 100, the main PTC 12 of large thermal capacity is cooled to ordinary temperature. On the other hand, the auxiliary PTC 14 is small in thermal capacity and is hence quick to cool. Therefore, if attempted to start again right after stopping the single-phase induction motor 100, since the auxiliary PTC 14 is quickly cooled nearly to ordinary temperature, and it is ready to restart shortly, in about several seconds to dozens of seconds, and it is started quickly without repeating operation and reset of overload relay as in the prior art.

Continuously, the mechanical structure of overload relay 50 in the first embodiment is explained by referring to FIG. 3 and FIG. 4.

FIG. 3 is a plan view of overload relay 50 with the cover removed. FIG. 4 is a section view X-X in FIG. 3, with the cover attached. As shown in Fig. 4, the overload relay 50 is composed of a base 52 made of unsaturated polyester, and a cover 54 of PBT resin, and on the top of the overload relay 50, a socket terminal 58 is disposed for inserting a pin (not shown) extending

from the motor side, and a tab terminal 56 shown in Fig. 3 is disposed at the side surfaced for extending sideways and inserting power source side receptacle.

The overload relay 50 is composed as shown in Fig. 4 (A), in which bimetal 70 is held between movable contact plate 60 and movable side terminal 74, and a heater 76 is disposed beneath the bimetal 70. The movable contact plate 60 is disposed above the bimetal 70. One end of the movable contact plate 60 is welded and fixed to a reinforcing plate 78, and a movable contact 62 contacting with a fixed contact 64 is attached to the free end.

The mechanical structure of the overload relay 50 is more specifically described below.

The tab terminal 56 connected to the power source side receptacle is formed as a flat plate as shown in Fig. 3, and a connection plate 72 formed in a crank shape is spot-welded to the tab terminal 56, and is connected to terminal 76a of heater 76 by way of connection plate 72. The heater 76 is formed of, for example, nichrome or iron chrome wire wound in a coil form, and is accommodated in a recess 52c (see Fig. 4 (A)) formed in a base 52. As shown in Fig. 3, other end 76b of heater 76 is connected to reinforcing plate 78 by way of movable side terminal 74. As shown Fig. 4 (A), the reinforcing plate 78 is welded to the movable side terminal 74, penetrating through hole in the movable contact plate 60 and recess in the bimetal 70.

The bimetal 70 comprises a rectangular snap 70a, and a pair of holder 70b, 70b for holding the snap 70a, and the snap 70a is formed same as a flat bimetal, and is inverted in curvature (concave and convex relation) at a specified temperature. As shown in Fig. 4 (A), the bimetal 70 has its holders 70b enclosed and fixed between the movable contact plate 60 and movable side terminal 74, and the snap 70a is supported on a columnar support 52a formed in the base 52. Around the support 52a, the heater is disposed in a coil form in the recess 52c, so that the heat

generated in the heater 76 is efficiently transmitted to the bimetal 70.

The bimetal 70 is fixed on the holders 70b, and the snap 70a is supported on the support 52a, and desired characteristic is obtained by assembling only without requiring adjustment. In particular, since the holders 70b are smaller than the snap 70a, if the holders 70b are fixed, the snap characteristic is same as in the single bimetal of prior art (bimetal not fixed), and required characteristic may be obtained easily.

On the other hand, the movable contact plate 60 is made of elastic metal plate, and has a movable contact point 62 at free end, and a bump 60a contacting with the free end 70a' of the bimetal is disposed nearly in the center.

As shown in Fig. 4 (A), the movable contact 62 of the movable contact plate 60 fixed to the reinforcing plate 78 contacts with the fixed contact point 64 and a fixed contact plate 66 having the fixed contact point 64 has its one end 66a fixed to the base 52 side as shown in Fig. 4 (A), and other end 66b extended to outside by way of a through-hole or notch (not shown) formed in the cover 54. Outside the cover 54, other end 66b of fixed contact plate and socket terminal 58 are connected with each other.

As shown in Fig. 4 (B), a bump 54a is formed in the cover 54 of the overload relay 50, and the movable contact plate 60 is allowed to oscillate upward. The cover 54 also has an engaging portion 55 for coupling with the starter 10.

The overload relay 50, as shown in Fig. 4 (A), supplies the current from the power source entered through the tab terminal 56 to the motor M side as the movable contact point 62 and fixed contact point 64 contact with each other before the bimetal 70 is inverted (snaps).

When overcurrent flows due to overload of the motor M or confinement of rotor, the heat generation in the heater 76

increases, and when the bimetal 70 reaches a preset temperature (for example, 120 deg. C), it snaps from the convex state to concave state as shown in Fig. 4 (B), thereby pushing up the movable contact plate 60, and the contact of the movable contact point 62 and fixed contact point 64 is cut off. As a result, power supply to the motor M is stopped, and the motor is protected. By stopping of power supply to the motor M, flow of current to the hater 76 is stopped, and the temperature of the bimetal 70 declines. Reaching a predetermined temperature, snapping to concave state to convex state, as shown in Fig. 4 (A), the contact of the movable contact point 62 and fixed contact point 64 is restored by elasticity of movable contact plate 60, and power supply to the motor M is resumed.

Continuously, the mechanical structure of starter 10 in the first embodiment is explained by referring to FIG. 5 and FIG.6.

FIG. 5 (A) is a bottom view removing bottom cover of starter of single-phase induction motor of the first embodiment of the invention, FIG. 5 (B) is a sectional view of B1-B1 in FIG. 5 (A), and FIG. 5 (C) is a sectional view of C1-C1 in FIG. 5 (B). In addition, FIG. 5 (B) corresponds to a sectional view of B2-B2 in FIG.5 (C). FIG. 6 (A) is a plan view from arrow e side of FIG. 5 (B), FIG. 6 (B) is a side from arrow f-view in FIG. 5 (C), and FIG. 6 (C) is a bottom from arrow g-view in FIG. 5 (B). As shown in FIG. 6 (B), the starter 10 comprises a casing 40 and a bottom lid 46, and a flange 48 is formed so as to install an overload relay 50 as shown in FIG. 6, in its outside.

As shown in FIG. 5 (A), the inside of the casing 40 has a terminal 22 connected to the auxiliary winding S side shown in FIG. 2. The terminal 22 includes integrally tab terminal 22C, socket terminal 22A, and coupler 22B for coupling them. The coupler 22B has a first connection plate 26 having a spring member 26B for holding the main PTC 12.

As shown in FIG. 5 (C), one end of second connection plate

30 is connected to the tab terminal 22C of the terminal 22. Spring member 30a at other end of second connection plate 30 applies spring pressure to the auxiliary PTC 14 and holds it. The auxiliary PTC 14 contacts with the base of the snap action bimetal 18. That is, the spring member 30a of the second connection plate 30, auxiliary PTC 14, base of snap action bimetal 18, and one end of third connection plate 32 contact with each other adjacently. Other end of third connection plate 32 is connected to tab terminals 24C of terminal 24 for connecting to the power line 98 side and main winding M shown in Fig. 2, The terminal 24 has tab terminal 24C and socket terminal 24A.

On the other hand, at the leading end side of the snap action bimetal 18, movable contact point 18a is provided, and contacts with the fixed contact point 36a of the fixed contact plate 36 formed in a crank shape. At the side wall side of the casing 40 of the movable contact point 18a, a stopper 49 is provided for defining the move of the movable contact point 18a. Other end of fixed contact plate 36 is connected to fourth connection plate 33, and other end of the fourth connection plate 33 is connected to a terminal 25 having tab terminal 25C and socket terminal 25A. The terminal 25 is connected to fifth connection plate 34 having a spring member 34B for holding the main PTC 12. The fifth connection plate 34 is of same member as the first connection plate 26.

The snap action bimetal 18 and auxiliary PTC 14 are accommodated in an enclosed compartment 44 formed by partition wall 42 provided at the inner side of the casing 40. The enclosed compartment 44 has an airtight structure. The second connection plate 30 is surrounding the enclosed compartment 44 by way of vent hole 42a provided in the side wall of the casing 40, and the third connection plate 32 by way of vent hole 42b, and the fourth connection plate 33 by way of vent hole 42c.

FIG. 7 (A) is a plan view of assembled state of overload

relay 50 in starter 10, FIG. 7 (B) is a side view, and FIG. 7 (C) is a bottom view. It is assembled by engaging the flange 48 of the starter 10 with the coupler 55 of the overload relay 50.

In the starter 10 in the first embodiment, since the snap action bimetal 18 and the auxiliary PTC 14 are accommodated in the enclosed compartment 44 in the casing 40, heat hardly escapes outside, and the OFF state of the snap action bimetal 18 can be maintained by a very small power consumption. Further, as the refrigerant of enclosed compressor, flammable gas (hydrocarbon compound of butane or the like) is used, and if the refrigerant leaks, it is contained within the enclosed compartment, and it is not ignited by the spark of opening and closing action of the snap action bimetal 18.

Further, since the auxiliary PTC 14 is directly contacting with the base of the snap action bimetal 18, the heat from the auxiliary PTC 14 can be effectively transferred to the snap action bimetal 18, and the OFF state of the snap action bimetal 18 can be maintained by the auxiliary PTC 14 of small power consumption.

The snap action bimetal 18 of the starter 10 in the first embodiment is more specifically described below by referring to FIG. 8.

FIG. 8 (A) is a plan view of snap action bimetal 18, and FIG. 8 (B), FIG. 8 (C) are magnified sectional views of starter shown in FIG. 5 (C).

The snap action bimetal 18 comprises a movable contact plate 18b for oscillating a movable contact point 18a having a rectangular opening formed in the center, a bimetal 18c, and a semicircular plate spring 18d interposed between a first support point P1 of movable contact plate 18b, and a second support point P2 of bimetal 18c. The leading end of the movable contact plate 18b is divided into two steps, and has two movable contact points 18a.

The plate spring 18d is made of spring member or bimetal, and is installed so as to force the movable contact 18b. That is, as shown in Fig. 8 (B), when the second support point P2 is shifted to the leading end side of the bimetal 18c at low temperature, than the line segment linking the support point P3 and first support point P1 of the movable contact plate 18b, the movable contact plate is forced so that the plate spring 18d may press the movable contact point 18a to the fixed contact point 36a side. Accordingly, immediately before the snap action bimetal 18 is cut off, in the zero state of contact pressure, the contact time of the movable contact point 18a and fixed contact point 36a is short, and the movable contact point 18a and fixed contact point 36a will not be opened or closed by vibration.

On the other hand, as shown in FIG. 8 (C), when the second support point P2 is shifted to the leading end side of the bimetal 18c at high temperature, than the line segment linking the support point P3 and first support point P1 of the movable contact plate 18b, the movable contact plate 18b is forced so that the plate spring 18d may move movable contact point 18a from the fixed contact point 36a side. That is, from the state shown in FIG. 8 (B), the bimetal 18C is curved upward, and when the second support point P2 rides on the upper side by surpassing the line segment (dead point) linking the support point P3 and first support point P1 of the movable point plate 18b, the thrusting force of the plate spring 18d is inverted, and the snap action bimetal 18 is changed as shown in Fig. 8 (C), changing over from movable contact point 18a to fixed contact point 36a, so that the contact can be changed over quickly. Therefore, the arc does not continue, rough contact or noise does not occur. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

The structure of the first connection plate 26 is more specifically described below by referring to FIG. 9. FIG. 9 (A)

is a magnified view of first connection plate 26 shown in FIG. 5 (A), FIG. 9 (B) is an arrow h-view of FIG. 9 (A), FIG. 9 (C) is an arrow j-view of FIG. 9 (A), and FIG. 9 (D) is a magnified perspective view of abutting portion with main PTC surrounded by circle D in FIG. 9 (C). As mentioned above, the fifth connection plate 34 is of same member as the first connection plate 26.

The first connection plate 26 is made of a conductive spring material such as plated stainless steel of copper, copper alloy or conductive metal plate. The first connection plate 26 comprises a connection portion 26A bent in a crank form as shown in FIG. 9 (A), and a pair of spring members 26B, 26B bent in U-form in a direction at right angle to the bending direction of the connection portion 26A as shown in FIG. 9 (B). The spring members 26B, 26B hold the main PTC 12 by elastic force, and connect electrically. As shown in FIG. 9(C), the spring members 26B, 26B have rectangular openings in the center of a pair of rectangular plates extending sideward, and form a pair of U-shapes facing at the opening side, composed of a pair of parallel portions 26c, 26c and linking portion 26d linking the parallel portions 26c, 26c, and the pair of U-shapes are bent in a U-section to the inner side. Near the leading end of the parallel portion 26c, by bending and protruding so that the linking portion 26d may come to the inner side, a contacting corner 26f abutting against the main PTC 12 is formed. As shown in FIG. 9 (B), the parallel portions 26c, 26c have a diaphragm 26e for reducing the contact surface area with the casing 40 and preventing heat conduction.

A through-hole 26h is formed in the folded portion of the spring member 26B side of the connection portion 26A. That is, in the first connection plate 26, the width of outer circumference (fuse) 26j of the through-hole 26 is 0.5 mm or less. When the current of starting winding S flows more than a specified time

(for example, 30 seconds), it is designed to melt down by the fuse 26j of the outer circumference of the through-hole 26h. As a result, if the main PTC 12 deteriorates to generate abnormal heat and cause thermal runaway to be nearly in short-circuited state, the fuse 26j is melted down by the current, and burning of starting winding S or starter itself may be prevented. In particular, since the through-hole 26h is formed in the bent portion, the abutting folding portion has an elasticity, and by keeping an elastic state, re-fusion of the fused part can be prevented at the time of fusion of the fuse 26j.

Further, as shown in FIG. 9 (D), the contacting corner 26f bent at an obtuse angle to contact with the main PTC 12 of the parallel portion 26c has a slot 26g provided parallel to the extending direction of the parallel portion 26c. As a result, the contact point of the contacting corner 26f with the main PTC 12 is divided to be doubled in number, and the entire spring member 26B contacts with the main PTC 12 at four positions of contacting corner 26f, in a total of eight positions, so that the contact reliability may be enhanced.

Continuously the structure of terminal 22 of the starter 10 is described by referring to FIG. 18 and FIG. 19.

FIG. 18 (A) is a magnified perspective view of portion surrounded by circle E in FIG. 5 (B), FIG. 18 (B) is a sectional view B3-B3 in FIG. 18 (A), FIG. 18 (C) is a sectional view C3-C3 in FIG. 18 (A) (with the inner side from the pin center being cut off), and FIG. 18 (D) is a perspective view of socket terminal 22 of the pin 116 inserted state. FIG. 19 (A) is a plan view of terminal 22 shown in FIG. 18 (A), FIG. 19 (B) is a sectional view B4-B4 in FIG. 19 (A), and FIG. 19 (C) is an arrow k-view of FIG. 19 (A).

The terminal 22 is, like the first connection plate 26, made of a conductive spring material such as plated stainless steel of copper, copper alloy or conductive metal plate. As shown

in FIG. 19 (A), the terminal 22 is integrally formed of tab terminal 22C, socket terminal 22A, and a linking portion 22B for linking them. The tab terminal 22C plaits down a pair of plate portions 22k, 22k, extending sideways in the axial direction of connection pin to the inner side, and forms a double structure as shown in FIG. 19 (B), and a strength is obtained. A through-hole 22l is pierced in the center of the tab terminal 22C. The linking portion 22B is formed like a crank, and a through-hole 22m is pierced in the center.

As shown in FIG. 19 (C), the socket terminal 22A folds a pair of plate portion 22d, 22d extending sideward in the axial direction of connection pin to the inner side, and the leading ends are formed in an arc to be matched with the columnar shape of the connection pin, and the leading ends are departed from each other to form a connection pin holder 22e. The connection pin holder 22e is divided into two sections as shown in FIG. 19 (A), into a leading end side first position 22g and an inner side second position 22h by a slit 22f in vertical direction to axial direction of connection pin. At the opposite side of the connection pin holder 22e (at the lower side in FIG. 19 (C)), a V-groove 22n is formed so as to improve contact with the connection pin. At the leading end of the first position 22g, a V-notch 22j is formed, and at the leading end of the V-groove 22n, similarly, a V-notch 22o is formed.

As shown in FIG. 18 (A), FIG. 18 (B), and FIG. 18 (C), a recess 40a for accommodating leading end 116a of connection pin 116 penetrating through connection pin holder 22e is pierced in the casing 40 for holding the terminal 22.

In FIG. 18 and FIG. 19, the socket terminal 22A of the terminal 22 is explained, and the socket terminal 24A of the terminal 24 and socket terminal 58 of overload relay 50 are also in two-section structure. The starter 10 in the first embodiment has the overload relay 50 as shown in FIG. 7, and is attached

to the pin terminal 110 of the compressor 102 as shown in FIG. 1 (A). FIG. 1 (B) is a perspective view of pin terminal 110. The pin terminal 110 has three connection pins 112, 114, 116, and socket terminal 58 is connected to connection pin 112, socket terminal 24A is connected to connection pin 114, and socket terminal 22A is connected to connection pin 116.

In the starter 10 and overload relay 50 of the first embodiment, the connection pin holder 22e of socket terminals 22A, 24A, 58 is divided into two sections, the leading end first position 22g and inner side second position 22h, and as shown in FIG. 18 (D), when galling force acts in X-direction and/or Y-direction when inserting the connection pin 116, spreading is limited to the leading end first position 22g of the connection pin holder 22e, and is not extended up to the inner side second position 22h. Hence, in the second position 22h, fatigue does not occur, and a favorable contact state with the connection pin is maintained, and damage by heating of contact portion does not occur.

The inserting effort required when inserting the connection pin is shown in FIG. 22. The axis of ordinates shows the insertion force, and the axis of abscissas denotes the pin insertion stroke. The chained line represents the insertion force when inserting the connection pin 212 into the socket terminal 122A of the prior art referring to FIG. 28. The solid line shows the insertion force when inserting the connection pin 116 into the socket terminal 22A in the first embodiment. The socket terminal 122A of the prior art shown in FIG. 28 (F) must push to spread open the entire connection pin holder (folding the plates 122d, 122d inside and forming the leading end in an arc so as to match with arc shape of the connection pin) 122e when starting insertion of the connection pin 212. Hence, a very large effort is needed when starting to insert, and the force becomes constant later.

On the other hand, in the socket terminal 22A of the first embodiment, when inserting into the connection pin, first the leading end first position 22g is spread, but as compared with the connection pin holder 122e of the socket terminal 122A of the prior art, it is enough to push open the first position 22g of half length in the axial direction, and only about half insertion force is enough. When the leading end of the connection pin 116 reaches the inner second position 22h (P2 in the diagram), the second position 22h begins to spread, but as compared with the connection pi holder 122e of the socket terminal 122A of the prior art, large force is not needed. In addition, being guided by the first position 22g, the applied force acts to insert the connection pin 116 vertically, and extra effort is not needed. Thus, in the socket terminal 22A of the first embodiment, when starting to insert the connection pin, it is enough to spread open only the divided leading end first position 22g, and the insertion work is much easier as compared with the prior art required to spread on the entire connection pin holder.

The socket terminal 22A of the first embodiment is same in size as in the prior art, and the space efficiency is high, and it is easily applicable to the existing starter.

If there is inclination between the connection pin 116 and socket terminal 22A, since the leading end first position 22g and inner side second position 22h contact with the connection pin 116 independently, and for example if the connection pin 116 and socket terminal 22A contact by point, the contact point is doubled in number, and the connection pin and socket terminal are connected electrically securely.

Moreover, as mentioned in relation to Fig. 18 (A), in the starter 10 of the first embodiment, since the recess 40a for holding the chamfered leading end 116a of the connection pin 116 penetrating through the connection pin holder 22e is provided in the casing 40, the chamfered leading end 116a of the leading

end of the connection pin 116 is positioned in the recess 40a penetrating through the connection pin holder 22e. In the prior art shown in FIG. 28 (D), FIG. 28 (E), since the chamfered leading end 212a is positioned within the connection pin holder 122e, the leading end 212a cannot be gripped, and the gripping force of the connection pin holder 122e is lowered. By contrast, in the starter of the first embodiment, since the leading end 116a of the chamfered connection pin 116 is not gripped by the connection pin holder 22e, the gripping force of the connection pin 116 in the connection pin holder 22e can be heightened. In particular, in the first embodiment, the gripping force is lowered by the portion of width of slit 22f shown in FIG. 21 (A), but by forming a recess 40a, the same gripping force can be obtained as the connection pin holder 122e of the same length as in the prior art without slit.

The socket terminal 2A of the first embodiment is set, as shown in Fig 19 (B), slightly larger in diameter $\phi 1$ of leading end first position 22g of the connection pin holder 22e than diameter $\phi 2$ of the inner side second position 22h. That is, the leading end first position 22g of the connection pin holder 22e formed wider than the inner side second position 22h so as to hold the connection pin 116 more softly, and a smaller force is needed when starting to insert the connection pin. On the other hand, since the inner second position 22h is formed narrow, and a favorable contact state with the connection pin 116 can be held by the second position 22h, and damage by heating of contact portion does not occur.

[Modified example of first embodiment]

Referring now to FIG. 10 and FIG. 11, the starter in the modified example of the first embodiment is described. FIG. 10 (A) is a plan view of snap action bimetal in a modified example of the first embodiment, FIG. 10 (B) is a sectional view of ON state of snap action bimetal 18 of the starter in modified example

of the first embodiment, and FIG. 10 (C) is a sectional view OFF state.

A shown in Fig. 10 (A), in the modified example of the first embodiment, the snap action bimetal 18 is composed of one bimetal, comprising movable contact plate 18e having a hole in the center and holding a movable contact point 18a, and a bimetal portion 18f provided in the center of the hole, and same as in the first embodiment, a plate spring 18d is interposed between a first support point P1 of the movable contact plate 18e and a second support point P2 of the bimetal portion 18f. As shown in FIG. 10 (B) and FIG. 10 (C), the operation of the snap action bimetal 18 is same as in the first embodiment shown] in FIG. 8 (B) and FIG. 8 (C), and the description is omitted.

FIG. 11 shows a first connection plate 26 in modified example of the first embodiment. FIG. 11 (A) is a magnified view of first connection plate 26 in a modified example of the first embodiment, FIG. 11 (B) is an arrow h-view of FIG. 11 (A), FIG. 11 (C) is an arrow j-view of FIG. 11 (A), and FIG. 11 (D) is a magnified perspective view of abutting portion with main PTC surrounded by circle D in FIG. 11 (C).

The first connection plate 26 in a modified example of the first embodiment is similar to the first connection plate in the first embodiment mentioned in Fig. 9. In the first embodiment, however, a slot 26g was formed in the contacting corner 26f parallel to the extending direction of the parallel portion 26c. By contrast in the modified example of the first embodiment, as shown in FIG. 11 (D), a notch 26m is provided in the contacting corner 26f parallel in the extending direction of the parallel portion 26c.

In the modified example of the first embodiment, a notch 26m is provided in the contacting angle 26f bent obtusely for contacting with the main PTC 12 of the spring member 26B for holding the main PTC 12. As a result, the contact point of the

contacting angle 26f and the main PTC 12 is divided and doubled in number, and the contact reliability is enhanced. Further, the resonance frequency of the contacting corner 26f is different between the inside and outside of the notch 26m. The main PTC 12 and spring member 26B resonate, and the electrode section of main PTC 12 is hit by the spring member 26B, and the electrode is damaged, and is peeled, but in the modified example, since the resonance frequency is different between the inside and outside of the contacting corner 26f, they do not resonate at the same time, and the contact portion 26f never hits the main PTC 12,

so that the electrode of main PTC 12 will not be damaged.

[Second embodiment]

The snap action bimetal 18 of the starter in the second embodiment is explained by referring to FIG. 12.

FIG. 12 (A) is a plan view of snap action bimetal 18 of starter in the second embodiment, and FIG. 12 (B) is a side view. FIG. 12 (C) is a plan view of snap action bimetal 18 of starter in other example of the second embodiment, FIG. 12 (D) is a side view of other example. FIG. 12 (E) is an explanatory diagram of ON state of snap action bimetal 18 of the second embodiment, and FIG. 12 (F) is an explanatory diagram of OFF state.

As shown in FIG. 12 (A), a slot is formed near the center of bimetal of flat plate of snap action bimetal 18, and the central portion 18h around the slot is not processed, and two positions 18g are processed by drawing at both sides of the slot. FIG. 12 (C) and FIG. 12 (D) are other examples of drawing at position 18g only. As shown in FIG. 12 (E) and FIG. 12 (F), the snap action bimetal 18 realizes snap action by drawing process.

In the starter of the second embodiment, since the snap action bimetal 18 is made of a bimetal processed by drawing 18h, so that the contact point can be cut off quickly. Therefore, the arc does not continue, rough contact or noise does not occur.

Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

Continuously the structure of the terminal 22 of the starter 10 in the second embodiment is described by referring to FIG. 20.

FIG. 20 (A) is a plan view of terminal 22 of starter in the second embodiment, FIG. 20 (B) is a sectional view B4-B4 in FIG. 20 (A), and FIG. 20 (C) is an arrow k-view of FIG. 20 (A).

The starter in the second embodiment is same as that of the first embodiment shown in FIG. 5 and FIG. 6. In the first embodiment, however, the leading end first position 22g of the connection pin holder 22e of the socket terminal 22A and the inner side second position 22h were equal in length in the connection pin axial direction. In the second embodiment, the length of the leading end first position 22g of the connection pin holder 22e is formed to be longer than of the length of the inner side second position 22h in the connection pin axial direction. Accordingly, the galling force when inserting the connection pin is received in the first position 22g, and spreading of galling force into the second position 22h is arrested. Hence, a favorable contact state with the connection pin 116 is maintained at the second position 22h, and damage by heating of connection portion does not occur.

[Modified example of second embodiment]

Referring now to FIG. 13, the snap action bimetal 18 of the starter in the modified example of the second embodiment is described. FIG. 13 (A) is a plan view of snap action bimetal 18 of the starter in a modified example of the second embodiment, FIG. 13 (B) is a side view, FIG. 13 (C) is an explanatory view of ON state of snap action bimetal 18 in modified example of the second embodiment, and FIG. 13 (D) is an explanatory view OFF

state.

A shown in Fig. 13 (A), the snap action bimetal 18 is processed with slight forming 18i in the center of the plate. As shown in FIG. 13 (C) and FIG. 13 (D), the snap action bimetal 18 can realize snap action by forming processing.
For the starter in the modified example of the second embodiment, the snap action bimetal 18 is composed of a bimetal processed by forming 18i, and the contact point can be cut off quickly. Therefore, the arc does not continue, rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

[Third embodiment]

The bimetal 18 of the starter in the third embodiment is explained by referring to FIG. 14.

FIG. 14 (A) is an explanatory diagram of ON state of bimetal 18 of the third embodiment, and FIG. 14 (B) is an explanatory diagram of OFF state of the bimetal 18.

The bimetal 18 of the third embodiment comprises, same as in the first and second embodiment, an auxiliary PTC disposed at the base and a movable contact point 18a at the free end side. A magnet 23A for applying magnetic force to the bimetal 18 in a direction of forcing the movable contact point 18a to the fixed contact point 36a side is provided adjacently to the bimetal 18. Other configuration is same as in the first embodiment explained in FIG. 1 to FIG. 9, and the explanation is omitted.

In the starter of the third embodiment, the bimetal 18 having the movable contact point 18a at the free end side is forced to the contact ON side by the magnetic force of the magnet 23A. When the bimetal 18 is cut off, the magnetic force of the magnet 23A decreases inversely proportional to the square of the distance. Therefore, the bimetal 18 has the strongest magnetic

force in the movable contact point 18a ON state as show in FIG. 14 (A), and after the movable contact point 18a leaves as shown in FIG. 14 (B), the magnetic force decreases suddenly, so that the movable contact point 18a can be cut off quickly from the fixed contact point 36a. Therefore, the arc does not continue, rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

Continuously the structure of the terminal 22 of the starter 10 in the third embodiment is described by referring to FIG. 21.

FIG. 21 (A) is a plan view of terminal 22 of starter in the third embodiment, FIG. 21 (B) is a sectional view B4-B4 in FIG. 21 (A), and FIG. 21 (C) is an arrow k-view of FIG. 21 (A).

The starter in the third embodiment is same as that of the first embodiment shown in FIG. 5 and FIG. 6. In the first embodiment, however, the leading end first position 22g of the connection pin holder 22e of the socket terminal 22A and the inner side second position 22h were equal in length in the connection pin axial direction. In the third embodiment, the length of the inner side second position 22h of the connection pin holder 22e is formed to be longer than of the length of the leading end first position 22g in the connection pin axial direction. Accordingly, by holding the connection pin 116 firmly by the second position, 22h, fatigues does not occur, and a favorable contact state with the connection pin 116 is maintained, and damage by heating of connection portion does not occur.

In the third embodiment, a V-notch 22p is cut at the leading end of the inner side second position 22h of the connection pin holder 22e. When inserting into the connection pin 116, after the leading end of the connection pin 116 passing through the leading end first position 22g reaches the inner side second

position 22h, it is easy to insert into the second position 22h side, and the inserting operation is easy.

[Fourth embodiment]

The switch 18 of the starter in the fourth embodiment is explained by referring to FIG. 15.

FIG. 15 (A) is an explanatory diagram of ON state of switch 18 of the fourth embodiment, and FIG. 15 (B) is an explanatory diagram of OFF state of the switch 18.

The switch 18 of the fourth embodiment is composed of a magnetic conductive material, and has a movable contact point 18a provided at the free end side. A temperature sensing magnet 23B for applying magnetic force to the switch 18 in a direction of forcing the movable contact point 18a to the fixed contact point 36a side is provided immediately above the switch 18, and an auxiliary PTC is provided adjacently to the temperature sensing magnet 23B. Other configuration is same as in the first embodiment explained in FIG. 1 to FIG. 9, and the explanation is omitted.

In the starter of the fourth embodiment, the switch 18 made of magnetic conductive member having the movable contact point 18a at the free end side of spring plate senses heat from the auxiliary PTC, and when reaching the set temperature, it is forced by the magnetic force of the temperature sensing magnet 23B which is demagnetized. That is, at less than the set temperature as shown in FIG. 15 (A), the switch 18 is attracted by the magnetic force of the temperature sensing magnet 23B by resisting the elasticity of the spring plate and is turned on. On the other hand, when reaching the set temperature as shown in FIG. 15 (B), the switch 18 is turned off by the elasticity of the spring plate due to demagnetization of the temperature sensing magnet 23B. At this time of turning off, the magnetic force from the temperature sensing magnet 23B drops inversely proportional to the square of the distance. The switch 18 receives the strongest

magnetic force in the contact ON state, and after the movable contact point 18b leaves, the magnetic force decreases rapidly, so that the movable contact point 18a can be cut off quickly from the fixed contact point 36a. Therefore, the arc does not continue, rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

[Fifth embodiment]

The reed switch 19 of the starter in the fifth embodiment is explained by referring to FIG. 16.

In the fourth embodiment, the switch 18 composed of a magnetic conductive material is used, but in the fifth embodiment, the reed switch 19 is used instead of the switch. A temperature sensing magnet 23B for applying a magnetic force to the reed switch 19 in a direction of forcing to the contact ON side is provided immediately above the reed switch 19, and an auxiliary PTC 16 is provided adjacently to the temperature sensing magnet 23B. Other configuration is same as in the first embodiment explained in FIG. 1 to FIG. 9, and the explanation is omitted.

In the starter of the fifth embodiment, the reed switch 19 senses heat from the auxiliary PTC 16, and when reaching the set temperature, it is turned on or off by the magnetic force of the temperature sensing magnet 23B which is demagnetized. That is, at lower than the set temperature, the reed switch 19 is turned on by the magnetic force of the temperature sensing magnet 23B, and when exceeding the set temperature, the reed switch 19 is turned off by demagnetization of the temperature sensing magnet 23B. At this time of turning off, the magnetic force from the temperature sensing magnet 23B drops inversely proportional to the square of the distance, and the reed switch 19 is cut off quickly. Therefore, the arc does not continue,

rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

FIG. 17 shows the circuit of the starter 10 of the embodiment. Referring to FIG. 2, not limited to the circuit not using the capacitor, the starter 10 of the embodiment can be suitably used when running capacitor C1 is connected parallel to the starter 10 as shown in FIG. 17 (A), or when starting capacitor C2 is connected in series to the starter 10 as shown in FIG. 17 (B), or when starting capacitor C2 is connected in series to the running capacitor C1 parallel to the starter 10 as shown in FIG. 17 (C).

[Sixth embodiment]

The sixth embodiment is same as the first embodiment, and by referring to FIG. 1 to FIG. 7, its explanation is omitted. In the first embodiment, the snap action bimetal 18 used, but in the sixth embodiment, a slow action bimetal 18 is used.

The operation of the starter 10 in the sixth embodiment is explained. When the operation switch 97 is turned on, a starting current flows through the main winding M by way of the operation switch 97 and overload relay 50. Since the main PTC 12 is low in resistance (for example, about 5 ohms) at ordinary temperature, and starting current flows in both series circuit of auxiliary winding S, main PTC 12, and slow action bimetal 18, and parallel circuit of auxiliary PTC 14, and thereby the single-phase induction motor 100 is started up.

When starting current of auxiliary winding S flows into the main PTC 12, the main PTC 12 and auxiliary PTC 14 generate heat, and the electrical resistance increases rapidly. Several seconds later, the main PTC 12 and auxiliary PTC 14 reach the temperature of 140 deg. C, and the electrical resistance of the

main PTC 12 at this time is, for example, 1 to 10 kohms, and the current flowing in the slow action bimetal 18 decreases. When the auxiliary PTC 14 reaches the temperature of 140 deg. C, the slow action bimetal 18 senses it and is turned off, and no longer current flows into the series circuit of main PTC 12 and slow action bimetal 18, and the single-phase induction motor 100 is started up completely, and gets into stationary operation.

When the slow action bimetal 18 is turned off, current flows only into the auxiliary PTC 14 side, and heat is generated, and the slow action bimetal 18 senses the generated heat, and is kept in OFF state.

Therefore, during stationary operation of the single-phase induction motor 100, no current flows into the main PTC 12, and instead current flows into the auxiliary PTC 14 side, but the current flowing in the auxiliary PTC 14 side is very small only enough to generate heat for keeping the OFF state of the slow action bimetal 18, and the power consumption by the auxiliary PTC 14 is extremely smaller than the power consumption by the conventional positive characteristic thermistor. Further, since slow action bimetal is used, as compared with the formed snap action bimetal, it withstands use for a longer period of time.

During stationary operation of the single-phase induction motor 100, the main PTC 12 of large thermal capacity is cooled to ordinary temperature. On the other hand, the auxiliary PTC 14 is small in thermal capacity and is hence quick to cool. Therefore, if attempted to start again right after stopping the single-phase induction motor 100, since the auxiliary PTC 14 is quickly cooled nearly to ordinary temperature, and it is ready to restart shortly, in about several seconds to dozens of seconds, and it is started quickly without repeating operation and reset of overload relay as in the prior art. Further, the auxiliary PTC 14 is small in thermal capacity, it is possible to restart

shortly.

Continuously the mechanical structure of the starter 10 of the sixth embodiment is described by referring to FIG. 23 and FIG. 24.

FIG. 23 (B) is a plan view with the lid removed of starter of single-phase induction motor in the sixth embodiment of the invention, FIG. 23 (A) is a sectional view A-A of FIG. 23 (B), and FIG. 23 (C) is a sectional view C-C in FIG. 23 (B). FIG. 24 (A) is arrow e-view of FIG. 23 (B), and FIG. 24 (B) is arrow d-view of FIG. 23 (B). As shown in FIG. 24 (B), the starter 10 has a casing 40 and a lid 46, and has a flange 48 for mounting an overload relay 50 on the outside.

As shown in FIG. 23 (C), inside of the casing 40, a terminal 22 is provided to be connected to the auxiliary winding S side. The terminal 22 is integrally formed of tab terminal 22a, pin terminal 22c, and a coupler 22b for linking them. The coupler 22b has a first connection plate 26 having a spring member 26b for supporting main PTC 12. The first connection plate 26 is bent like a crank in the middle, and a through-hole 26a is formed in the bent portion to the spring member 26b side. That is, the first connection plate 26 is narrow at the through-hole 26a, and when a large current flows, it is designed to melt down at the outer circumference of the through-hole 26a.

One end of second connection plate 30 is connected to the spring member 26b. Spring member 30a at other end of the second connection plate 30 holds the auxiliary PTC 14 by applying spring pressure. The auxiliary PTC 14 contacts with the base of the slow action bimetal 18. That is, as shown in FIG. 23 (A) and FIG. 23 (B), the spring member 30a of the second connection plate 30, auxiliary PTC 14, base of slow action bimetal 18, and one end of third connection plate 32 are connected adjacently to each other. Other end of the third connection plate 32 is connected to the coupler 24b (see FIG. 23 (A)) of the terminal 24 for

connecting to the power line 98 side and main winding M. The terminal 24 is integrally formed of tab terminal 24a, pin terminal 24c, and a coupler 24b for linking them.

On the other hand, at the leading end of the slow action bimetal 18, movable contact point 18a is provided, and contacts with the fixed contact point 36a of the crank shaped fixed contact plate 36. Other end of the fixed contact plate 36 is fixed to the second spring 35 for holding the main PTC 12.

The slow action bimetal 18 and auxiliary PTC 14 are accommodated in the enclosed compartment 44 formed by L-shaped partition wall 42 provided inside of the casing 40. The enclosed compartment 44 has an airtight structure. The second connection plate 30 distributed in the enclosed compartment 44 by way of through-hole 42a provided in the partition wall 42, the third connection plate 32, by way of through-hole 42b, and the fixed contact plate 36 by way of through-hole 42c.

In the starter 10 of the sixth embodiment, since the slow action bimetal 18 and auxiliary PTC 14 are accommodated in the enclosed compartment 44 in the casing 40, heat hardly escapes outside, and the OFF state of the slow action bimetal 18 can be maintained by a very small power consumption. Further, as the refrigerant of the enclosed compressor, flammable gas (hydrocarbon compound such as butane) is used, and if the refrigerant leaks, since it is contained within the enclosed compartment 44, it is not ignited by spark when opening or closing the slow action bimetal 18.

Further, since the auxiliary PTC 14 directly contacts with the base of the slow action bimetal 18, heat from the auxiliary PTC 14 can be efficiently transmitted to the slow action bimetal 18, and the OFF state of the slow action bimetal 18 can be maintained by the auxiliary PTC 14 of small power consumption.

[Seventh embodiment]

The seventh embodiment of the invention is explained by

referring to FIG. 25 and FIG. 26. FIG. 26 is a circuit diagram of starter in the seventh embodiment.

The circuit configuration of the starter 10 of the seventh embodiment is same as in the starter of the sixth embodiment. However, in the seventh embodiment, a normally closed snap action bimetal 16 for protection from thermal runaway of the main PTC 12 is connected in series to the main PTC 12 and slow action bimetal 18.

The operation of the starter 10 in the seventh embodiment is explained. When the operation switch 97 is turned on, a starting current flows through the main winding M by way of the operation switch 97 and overload relay 50. Since the main PTC 12 is low in resistance (for example, about 5 ohms) at ordinary temperature, and starting current flows in both series circuit of auxiliary winding S, main PTC 12, and slow action bimetal 18, and parallel circuit of auxiliary PTC 14, and thereby the single-phase induction motor 100 is started up.

When starting current of auxiliary winding S flows into the main PTC 12, the main PTC 12 and auxiliary PTC 14 generate heat, and the electrical resistance increases rapidly. Therefore, the current flowing in the slow action bimetal 18 decreases. When the auxiliary PTC 14 reaches 140 deg. C, the slow action bimetal 18 detects it and is turned off, and no current flows into the series circuit of main PTC 12, snap action bimetal 16, and slow action bimetal 18, thereby finishing the starting procedure of single-phase induction motor 100.

When the slow action bimetal 18 is turned off, current flows only into the auxiliary PTC 14 side, and heat is generated, and the slow action bimetal 18 senses the generated heat, and is kept in OFF state.

Therefore, during stationary operation of the single-phase induction motor 100, no current flows into the main PTC 12, and instead current flows into the auxiliary PTC 14 side, but the

current flowing in the auxiliary PTC 14 side is very small only enough to generate heat for keeping the OFF state of the slow action bimetal 18, and the power consumption by the auxiliary PTC 14 is extremely smaller than the power consumption by the conventional positive characteristic thermistor.

During stationary operation of the single-phase induction motor 100, the main PTC 12 of large thermal capacity is cooled to ordinary temperature. On the other hand, the auxiliary PTC 14 is small in thermal capacity and is hence quick to cool. Therefore, if attempted to start again right after stopping the single-phase induction motor 100, since the auxiliary PTC 14 is quickly cooled nearly to ordinary temperature, and it is ready to restart shortly, in about several seconds to dozens of seconds.

The following is the explanation of the operation in case of abnormal heat generation of the main PTC 12 before actuation of the slow action bimetal 18 by the auxiliary PTC 14.

When the main PTC 12 generates abnormal heat to reach a specified high temperature, the snap action bimetal 16 is cut off, and current to the auxiliary winding S is cut off. As a result, the main PTC 12 thermally runs away and becomes low in resistance at high temperature, and insulation breakdown due to flow of large current into the auxiliary winding S can be prevented. In particular, since the snap action bimetal 16 is set so as not to reset at ordinary temperature, and thermal runaway of the main PTC 12 can be completely prevented.

The mechanical structure of the starter 10 in the seventh embodiment is explained by referring to Fig. 25. The side view of the starter 10 of the seventh embodiment is same as in the sixth embodiment shown in FIG. 24, by referring to this diagram, explanation of detail is omitted.

FIG. 25 (B) is a plan view with the lid removed of starter of single-phase induction motor in the sixth embodiment of the invention, FIG. 25 (A) is a sectional view A-A of FIG. 25 (B),

and FIG. 25 (C) is a sectional view C-C of FIG. 25 (B). FIG. 24 (A) is an arrow e-view of FIG. 25 (B), and FIG. 24 (B) is an arrow d-view of FIG. 25 (B).

As shown in FIG. 25 (C), inside of the casing 40, terminal 22 connected to the auxiliary winding S side shown in FIG. 26 is provided. The terminal 22 is integrally formed of tab terminal 22a, pin terminal 22c, and a coupler 22b for linking them. The coupler 22b has a first connection plate 26 having spring member 26b for holding the main PTC 12. The first connection plate 26 has its center bent like a crank, and a through-hole 26a is formed in the bent portion to the spring member 26b side. That is, the first connection plate 26 is narrow at the through-hole 26a, and it is designed to melt down at the outer circumference of the through-hole 26a when a large current flows.

One end of the second connection plate 30 is connected to the spring member 26b. Spring member 30a formed at other end of the second plate 30 applies a spring pressure to the auxiliary PTC 14 and holds it. The auxiliary PTC 14 contacts with the base of the slow action bimetal 18. That is, as show in FIG. 25 (A) and FIG. 25 (B), the spring member 30a of the second connection plate 30, auxiliary PTC 14, base of slow action bimetal 18, and one end of the third connection plate 32 are connected adjacently. Other end of the third connection plate 32 is connected to the coupler 24b (see FIG. 25 (A)) of the terminal 24 for connecting to the power line 98 side and main winding M shown in FIG. 26. The terminal 24 is integrally formed of tab terminal 24a, pin terminal 24c, and coupler 24b for linking them.

On the other hand, at the leading end of the slow action bimetal 18, movable contact point 18a is provided, and contacts with the movable contact point 16a of the snap action bimetal 16. The base of the snap action bimetal 16 is fixed to the second spring 35 in order to hold the main PTC 12. In the casing 40, on the other hand, a stopper 51 extending to the leading end of

the snap action bimetal 16 is provided, and it is configured so that the snap action bimetal 16 may not disturb the operation of the slow action bimetal 18.

In the starter 10 of the seventh embodiment, the movable contact point 18a of the slow action bimetal 18 and the movable contact point 16a of the snap action bimetal 16 directly contact with each other, and when the slow action bimetal 18 reaches the set temperature, it is departed from the movable contact point 16a of the snap action bimetal 16, and when the snap action bimetal 16 reaches the specified high temperature, it is departed from the movable contact point 18a of the slow action bimetal 18 side. When the slow action bimetal 18 is cut off by application of heat, heat is also applied to the snap action bimetal 16 side, and is moved slightly to be departed from the movable contact point 18a of the slow action bimetal 18, and therefore by using the slow action bimetal which is long in life but slow in action, the starting current can be cut off appropriately. That is, along with temperature rise, the bimetals depart mutually from each other, and chattering hardly occurs. Further, both contacts are made of movable contact points, and wiping (rubbing) phenomenon always occurs by temperature changes, and the contact portions of the movable contact portions 16a, 18a are cleaned, and a long life is realizing by using silver contact, instead of gold plating. Since the movable contact point 18a of slow action bimetal 18 and movable contact point 16a of snap action bimetal 16 directly contact with each other, lower cost and lower resistance can be realized as compared with the use of interposed terminal member of metal plate having fixed contact points in both.

In the starter 10 of the seventh embodiment, having a stopper 51 contacting with the leading end of the snap action bimetal 16, it is designed not to disturb operation of the slow action bimetal 18. Hence, after completion of starting, when the main PTC 12 is cooled and the snap action bimetal 18 returns

to ordinary temperature, warping to the slow action bimetal 16 side is prevented, and an adequate contact gap can be maintained.

INDUSTRIAL APPLICABILITY

The invention can be applied not only for driving the closed compressor of refrigeration cycle in refrigerator, but also for driving the closed compressor of refrigeration cycle of air conditioner, and further can be applied generally in appliances driven by single-phase induction motor of capacitor starting type or split phase starting type, and can be changed and modified within the scope not departing from the true spirit thereof.